When Earth Songs Filled the Void of Space

A story about how science works and about real people…

When Earth Songs Filled the Void of Space

The time of the story runs from 1894 to 2001,
but may include today…

Space [Merriam-Webster]: "the region beyond Earth's atmosphere or beyond the solar system"
Void [Merriam-Webster]: "containing nothing <*void* space>"

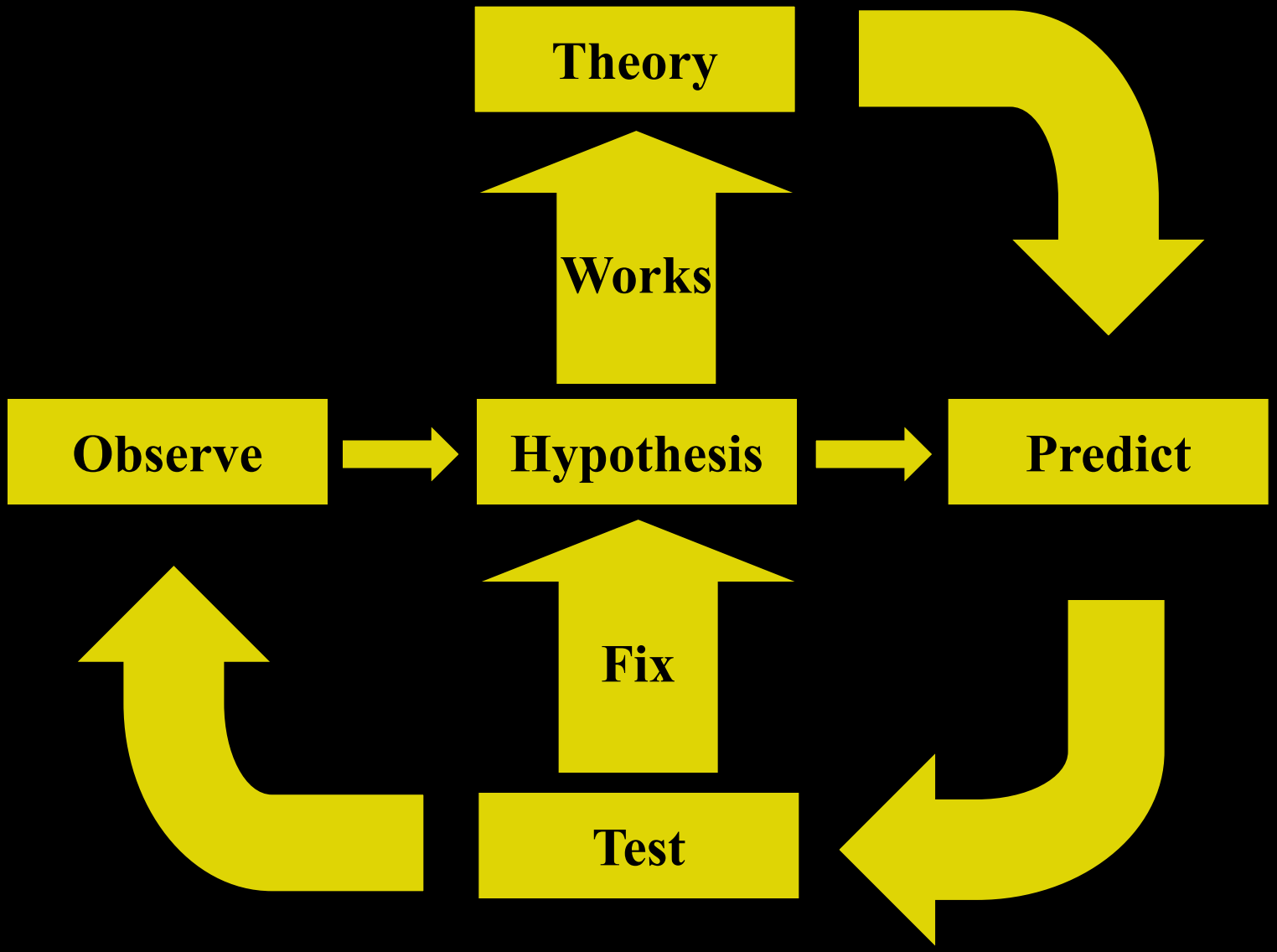
When Earth Songs Filled the Void of Space

So space or what we think about space is the topic

James Randi

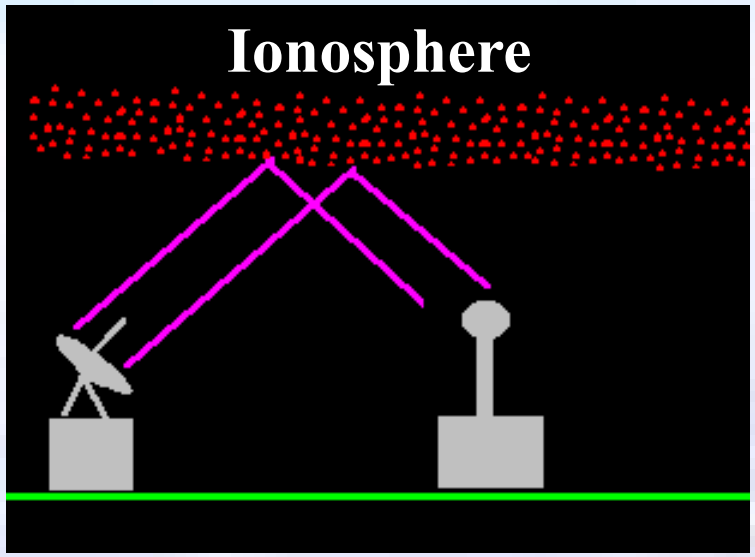
"Science is best defined as a careful, disciplined, logical search for knowledge about any and all aspects of the universe, obtained by examination of the best available evidence and always subject to correction and improvement upon discovery of better evidence. What's left is magic. And it doesn't work."

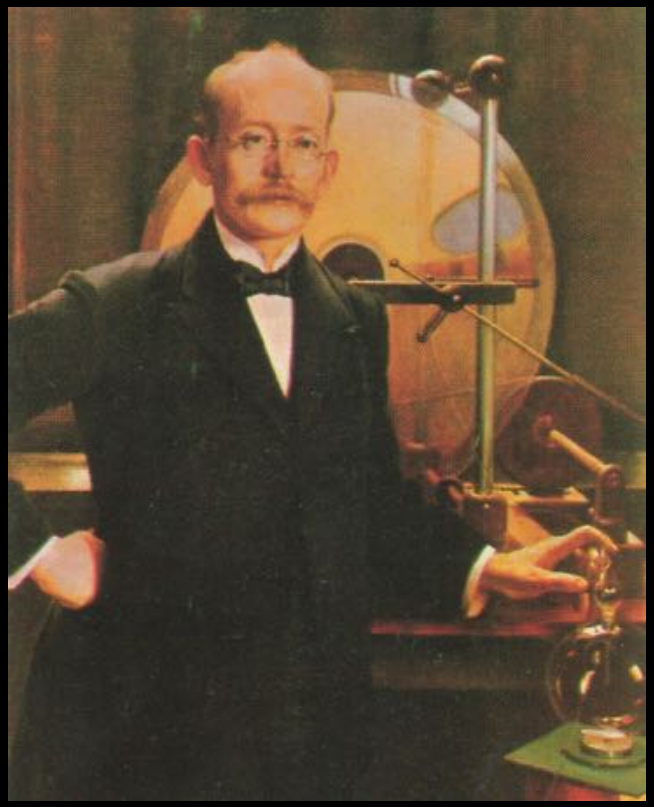
The Scientific Method

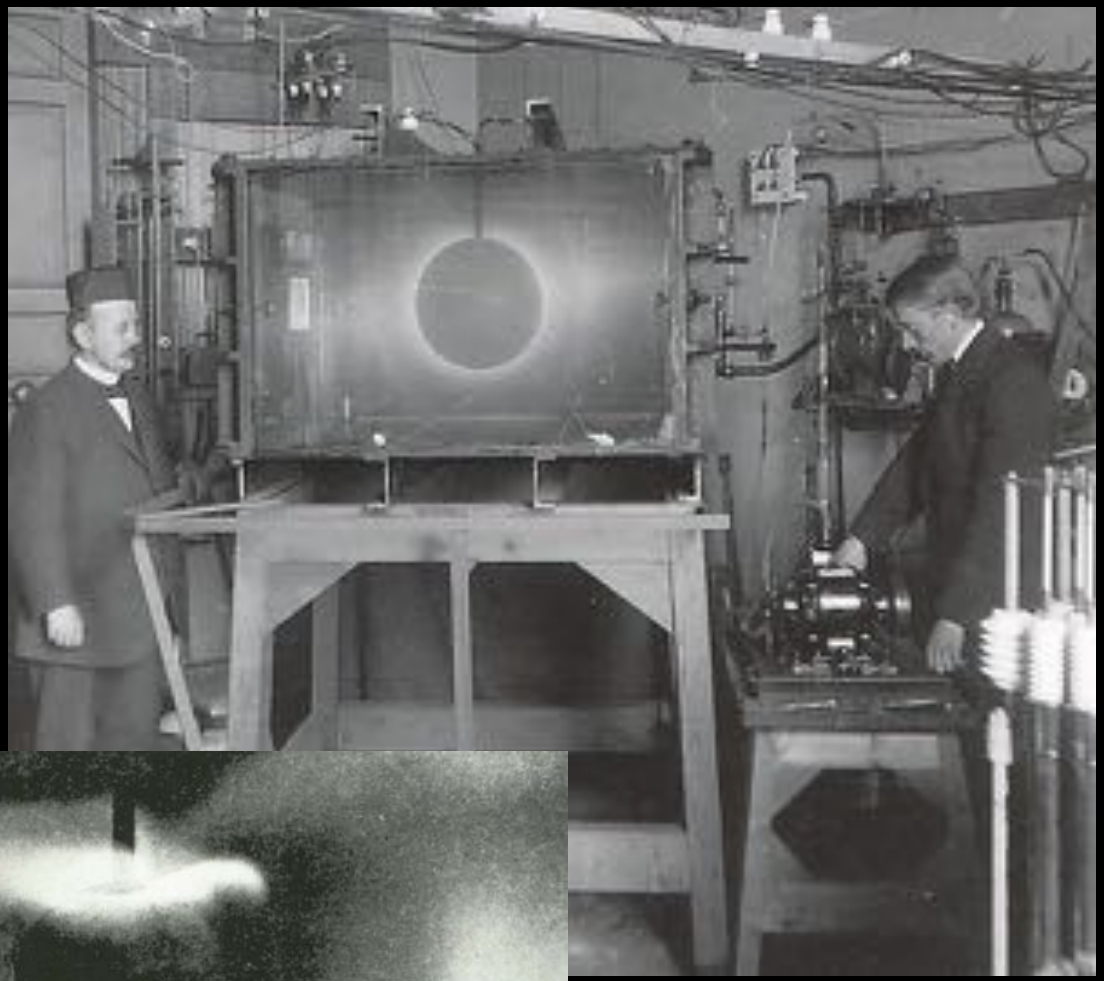


The Scientific Method

So Let's Observe a Little


Ionosphere

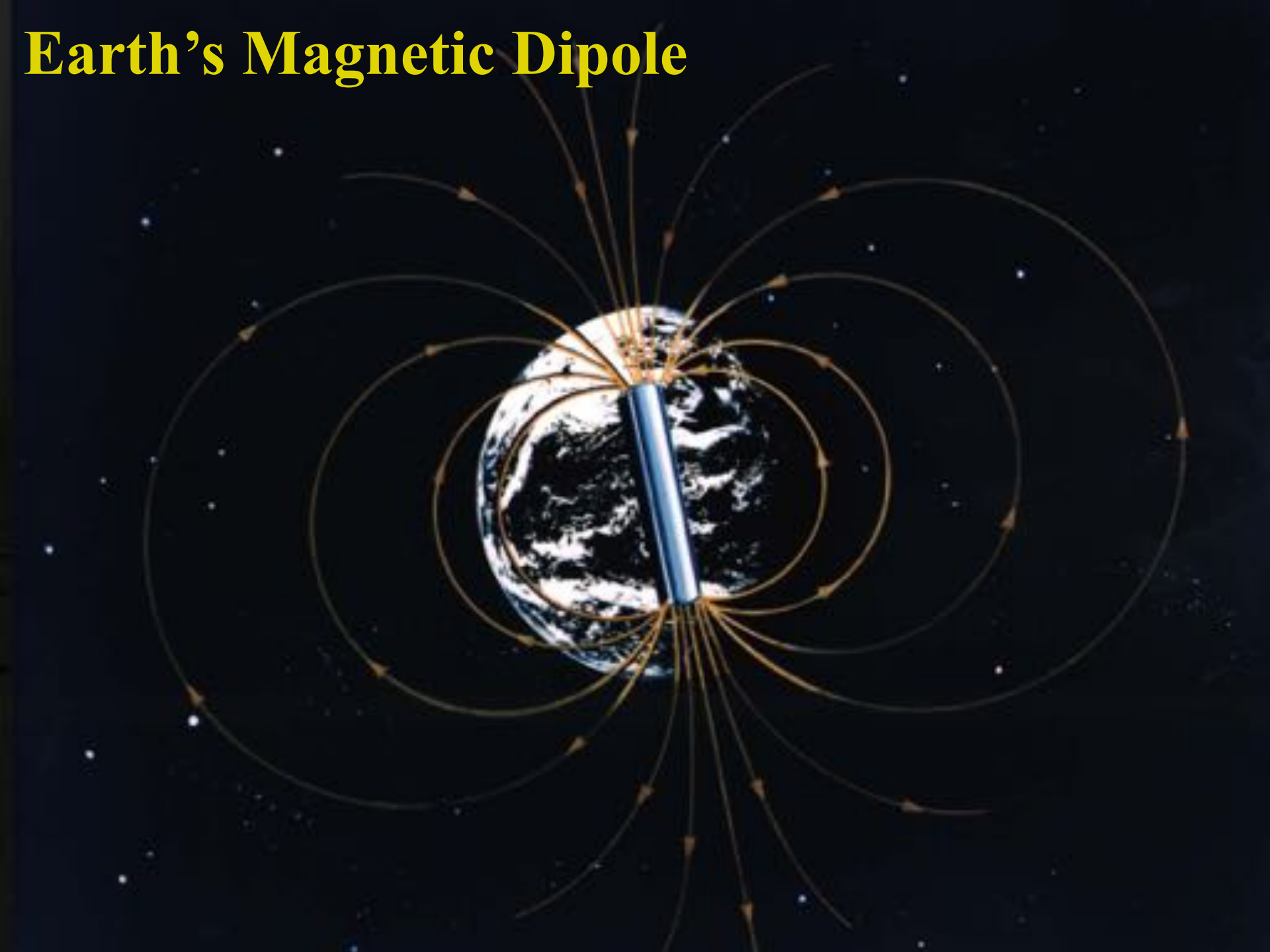




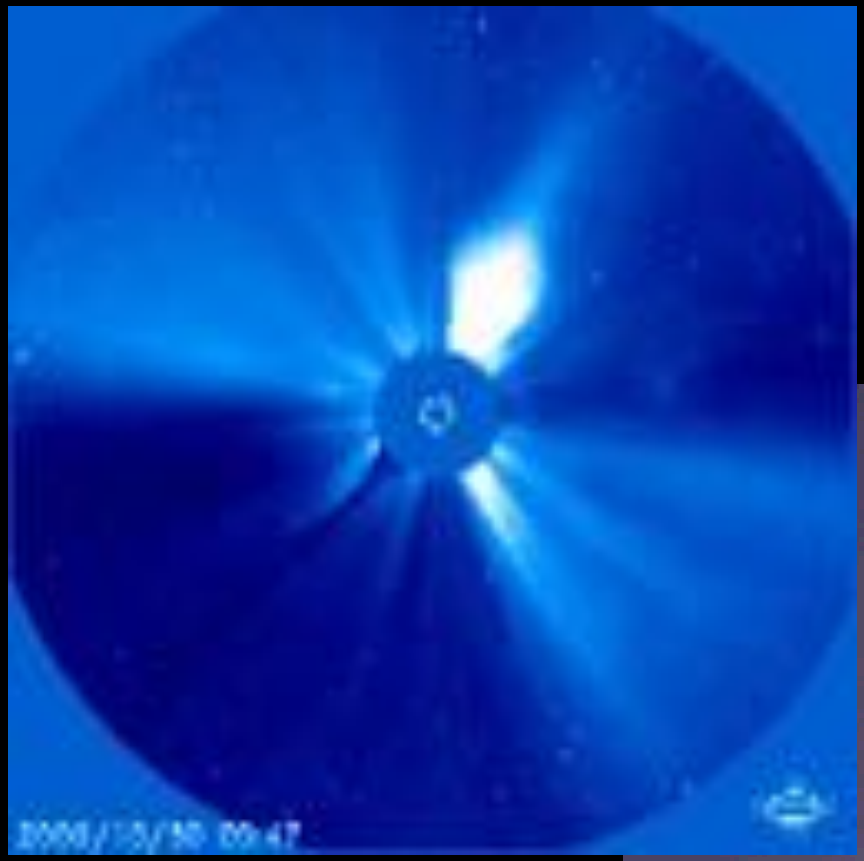
Birkeland's

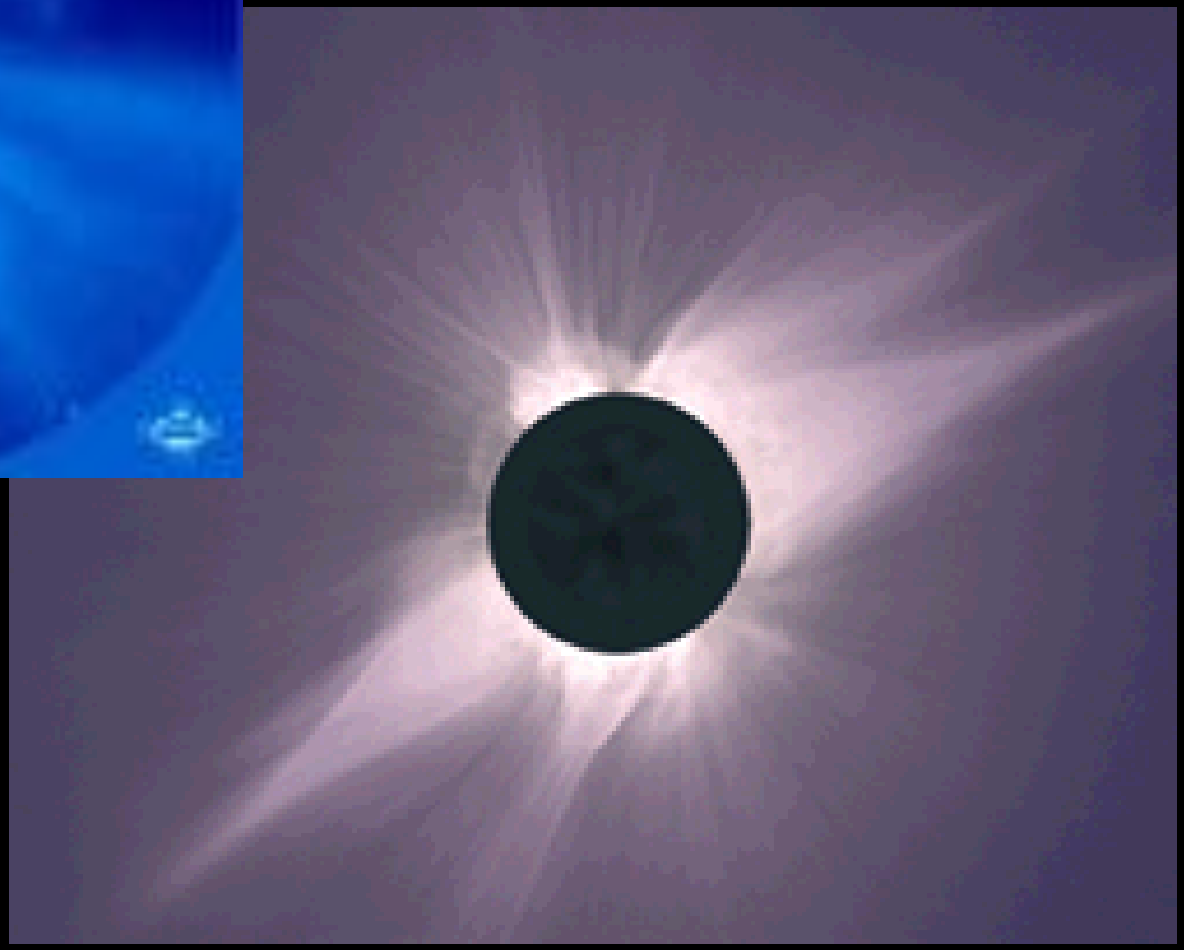
Terella Experiments in the 1890s

Earth's Magnetic Dipole

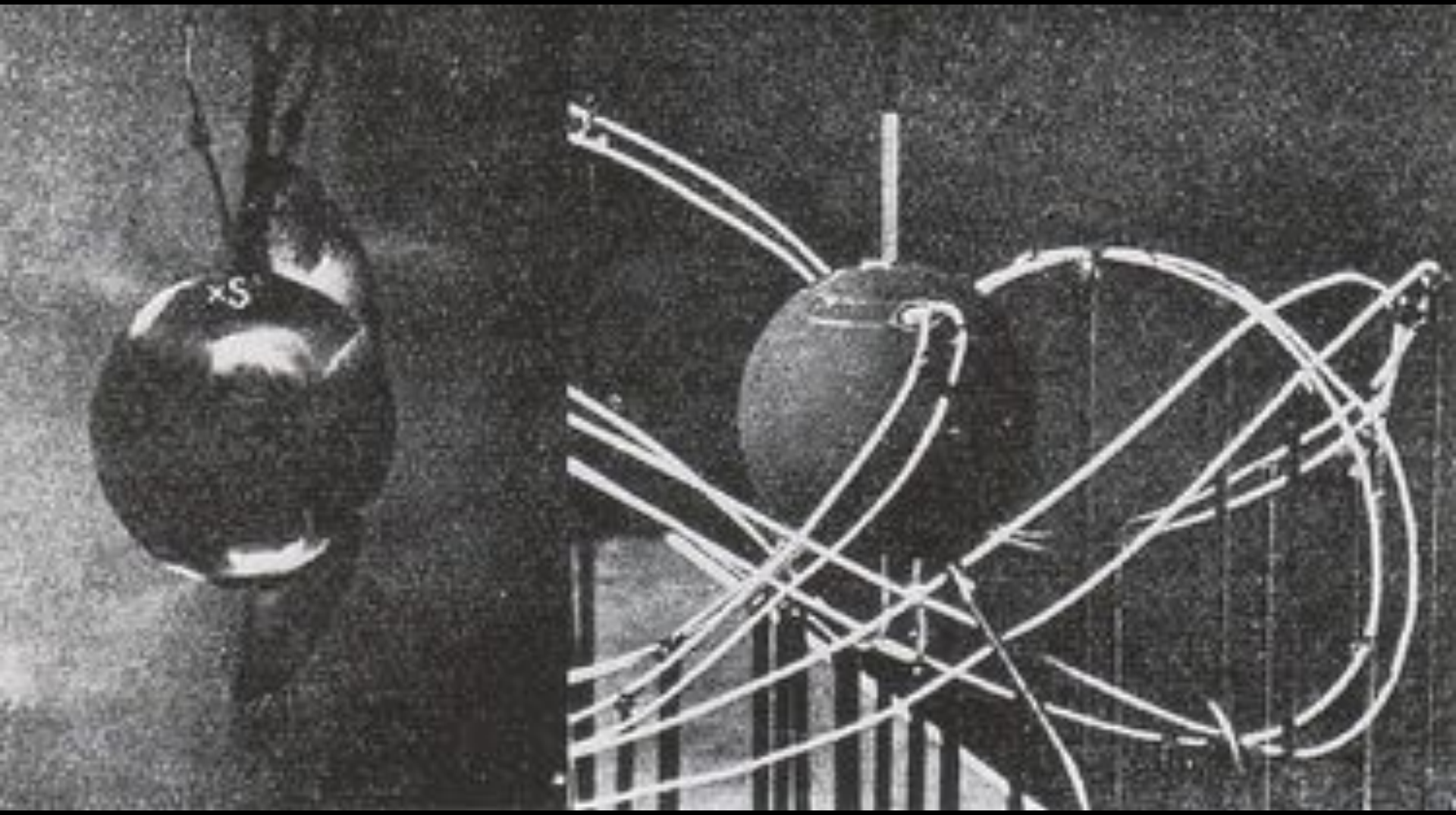


The Sun is a Copious Source of Plasma

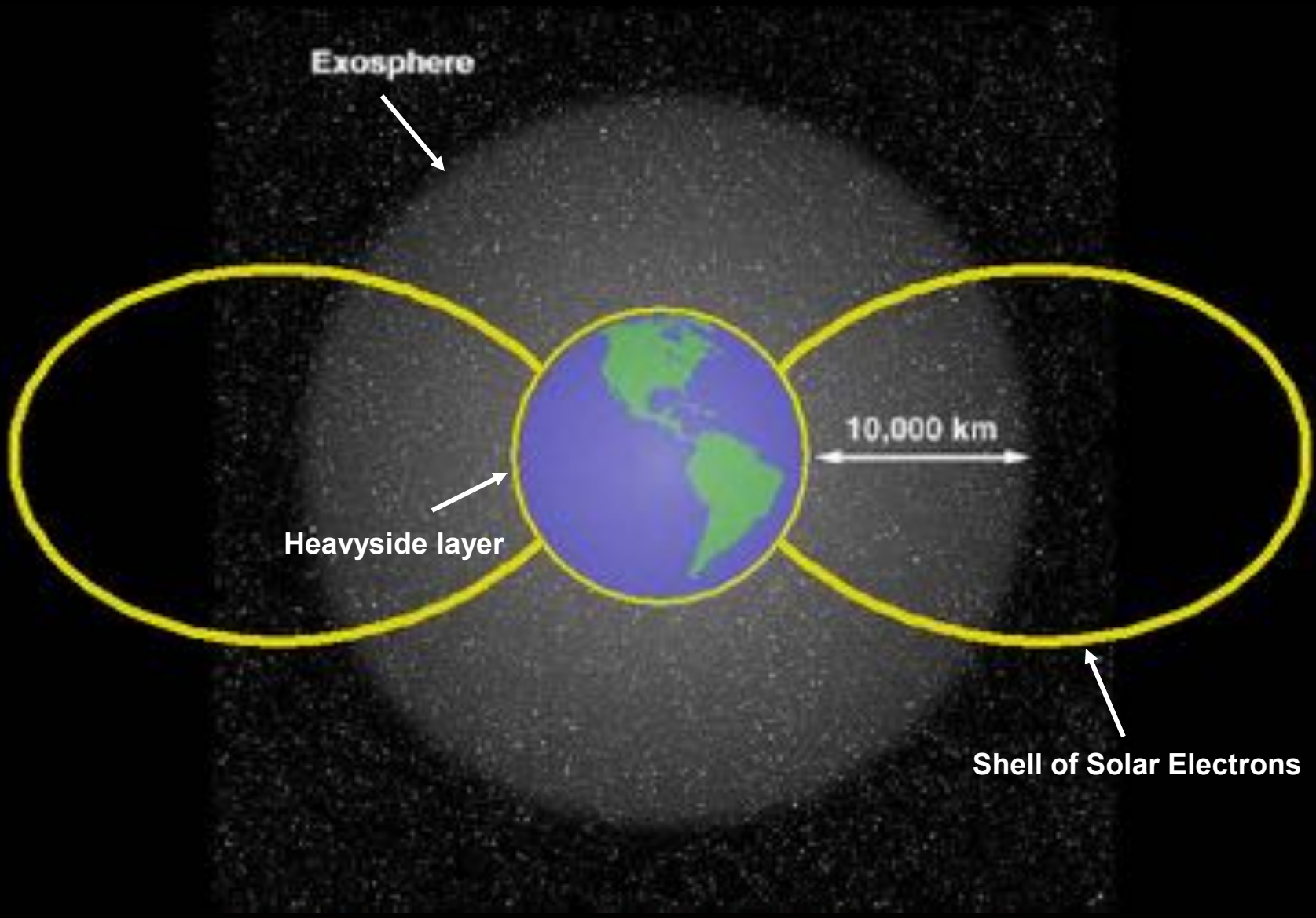




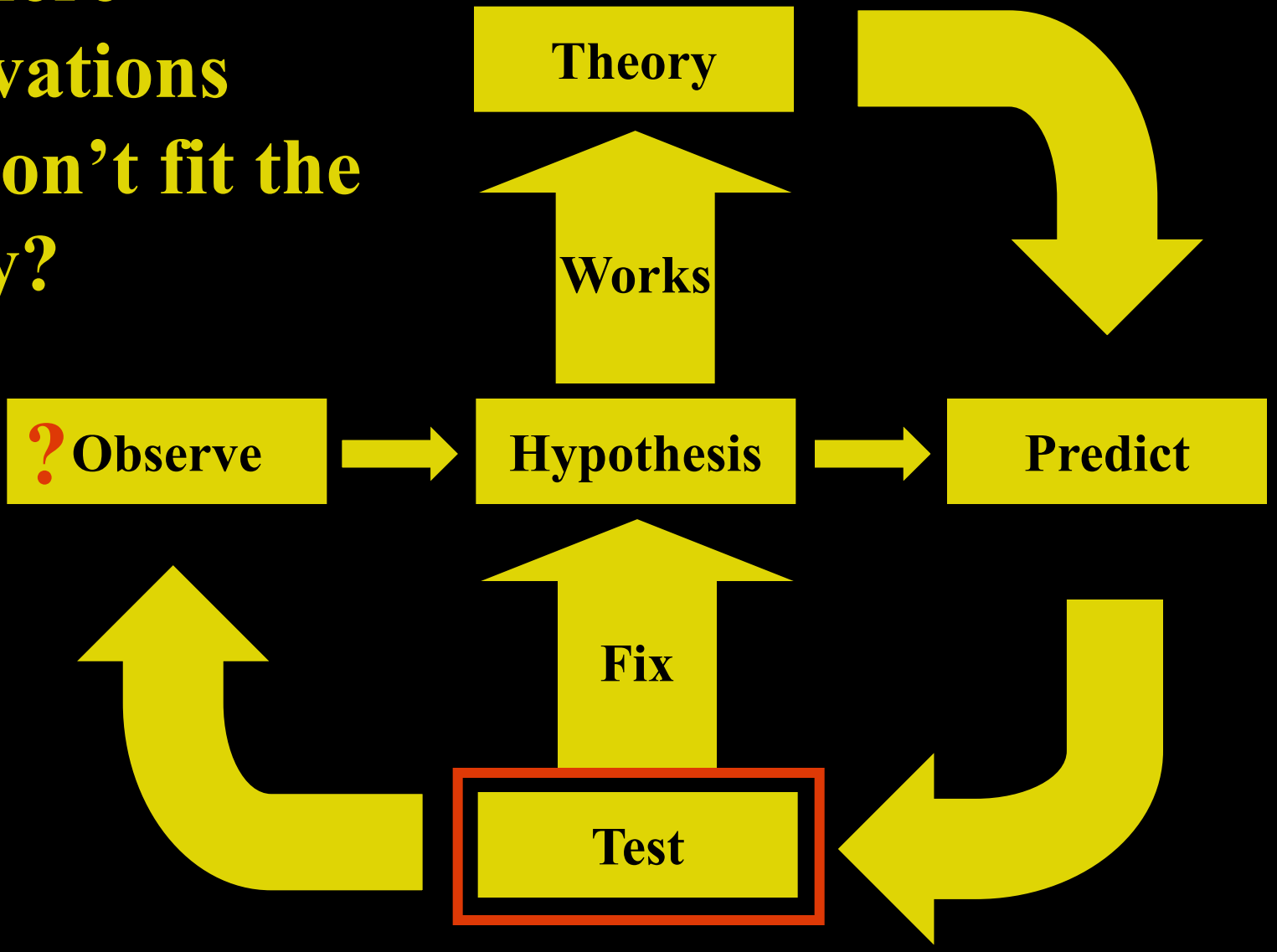
A Shell of Solar Electrons is Formed by Earth's B-field



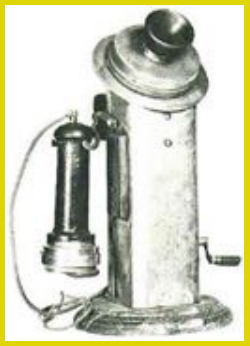
The 1950 Picture of Space Near Earth



So What's Next? Are there observations that don't fit the theory?



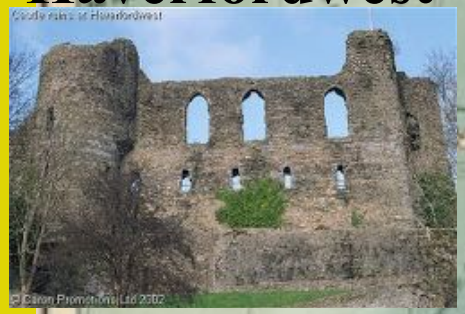
Legitimized Observations!



1894

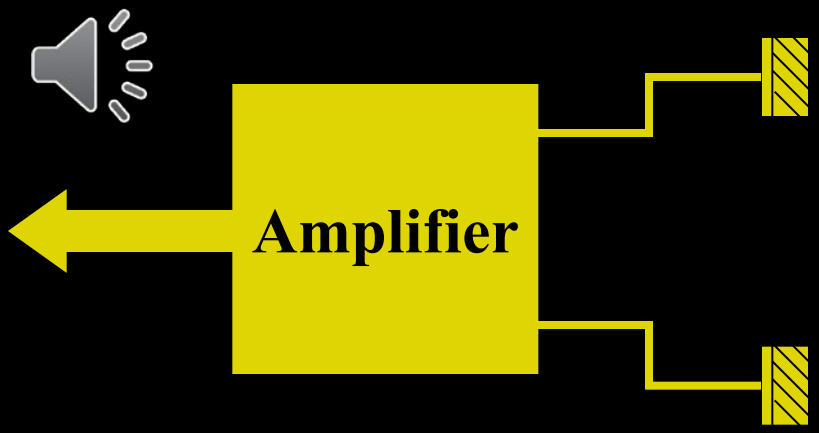
Llanfair

Haverfordwest

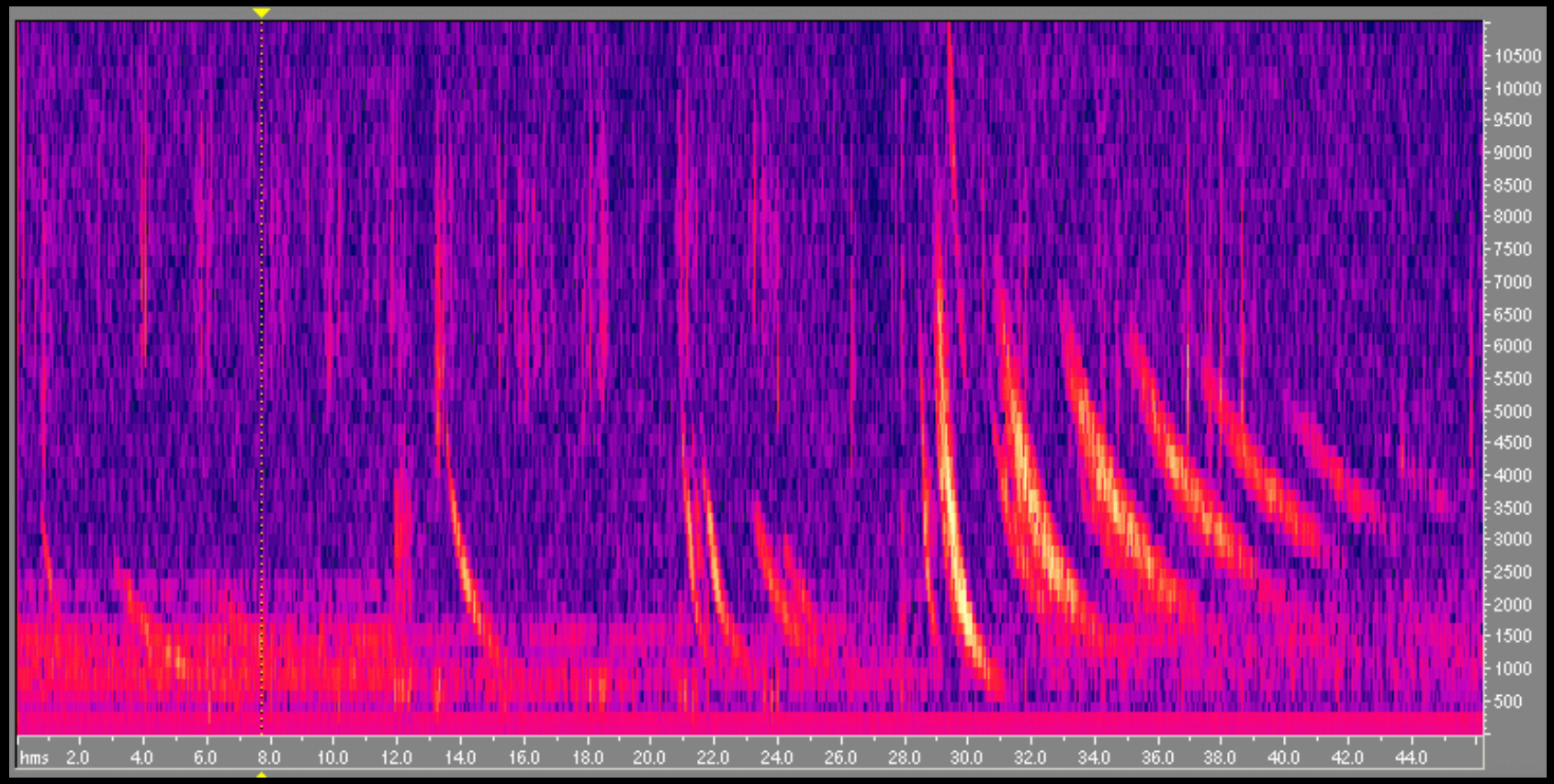


Lowestoft

World War I



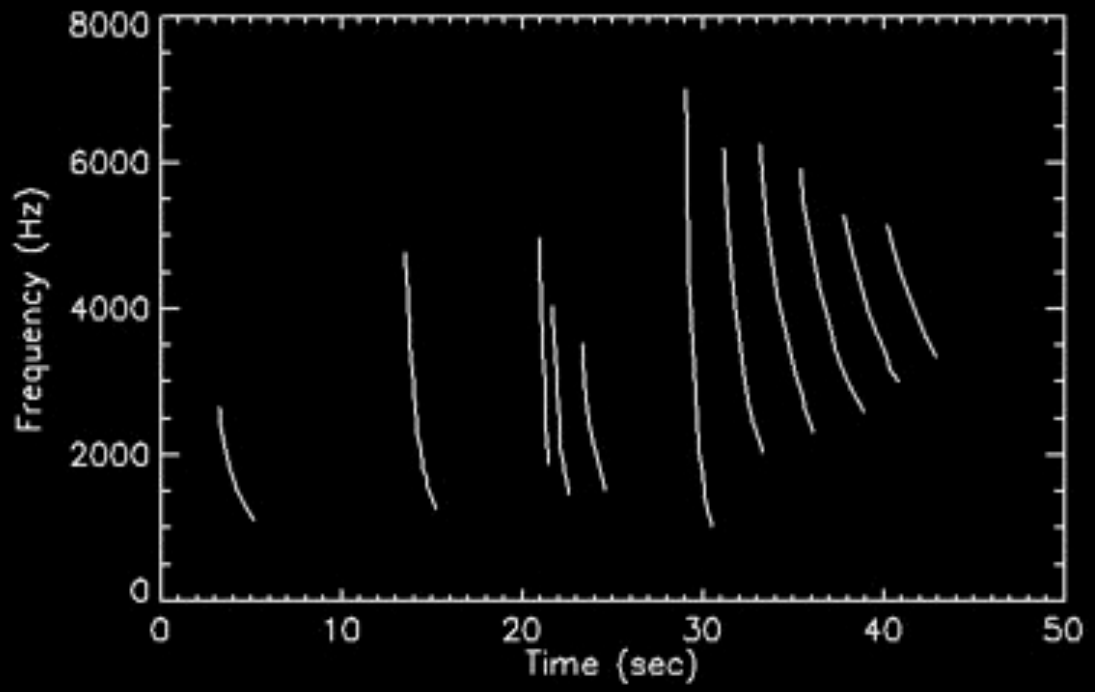
Burton and Boardman Introduced the Sound Spectrograph in 1930

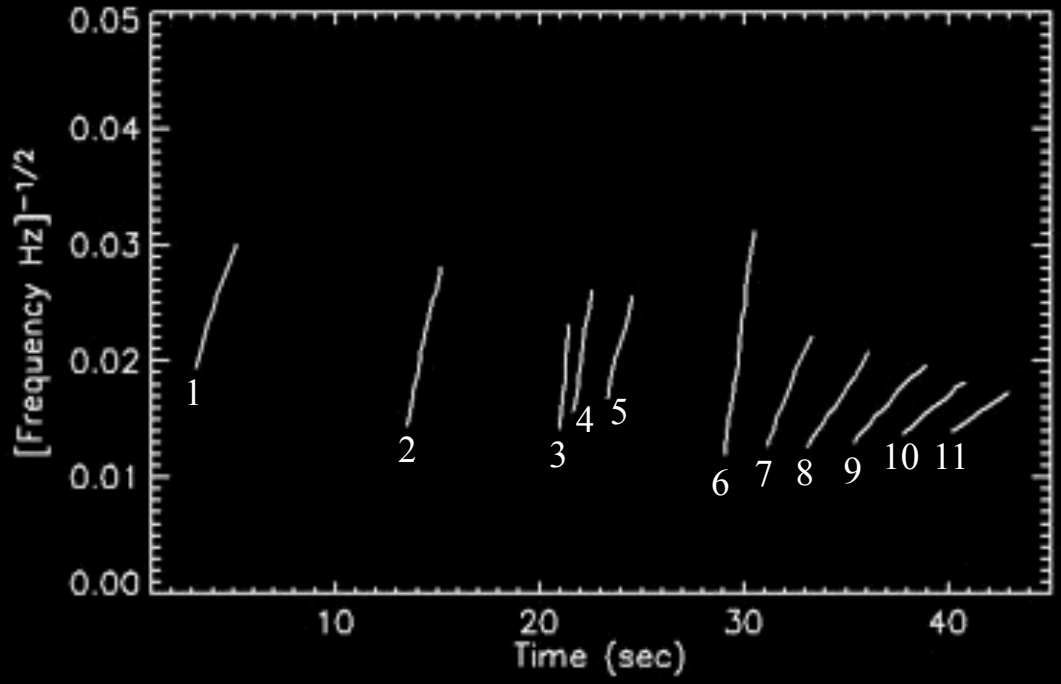


Frequency Dispersion

$$f^{-1/2} = t/D$$

Trace	D	T_0
1	186	-0.5
2	117	11.8
3	53	20.2
4	83	20.4
5	150	20.7
6	75	28.2
7	228	28.2
8	377	28.3
9	532	28.4
10	675	28.5
11	808	28.9





1952
L. R. Owen Storey
Cavendish Laboratory
University of Cambridge

Whistlers with Atmospherics

Whistlers without Atmospherics

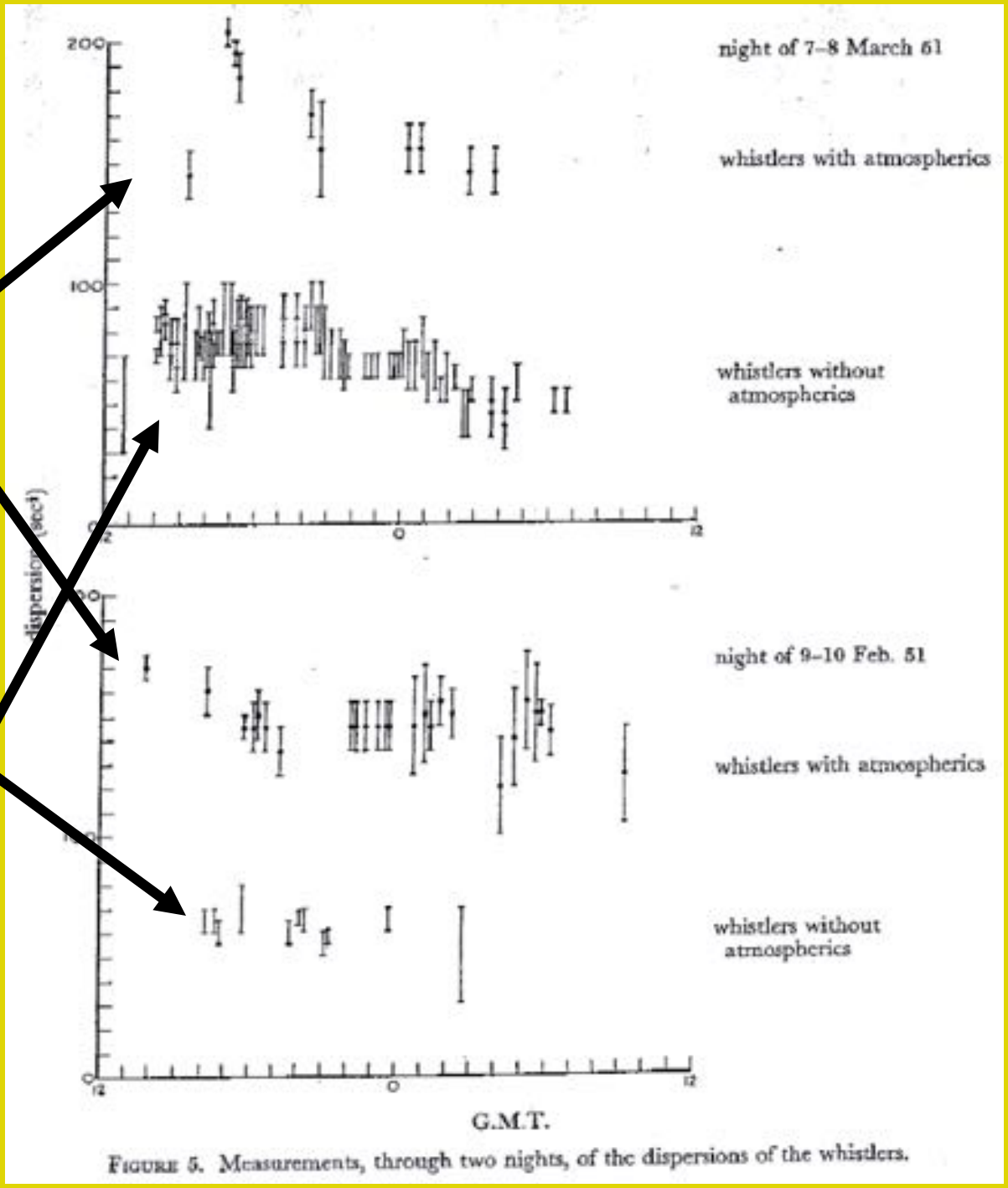


FIGURE 5. Measurements, through two nights, of the dispersions of the whistlers.

Multiple-flash

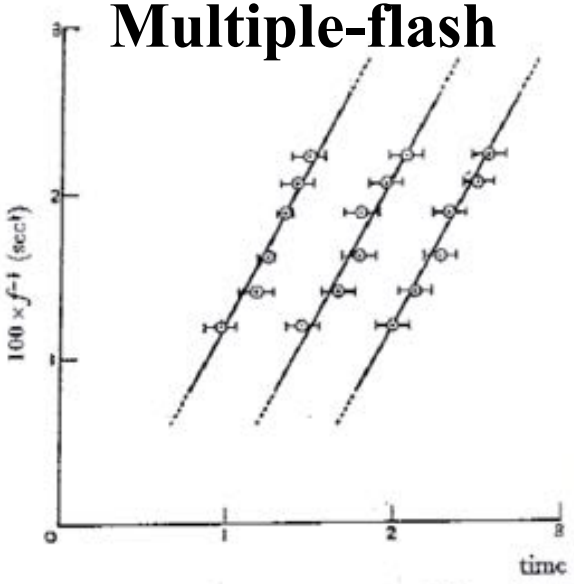


FIGURE 8. Multiple-flash type group of short whistlers.

Whistler pairs

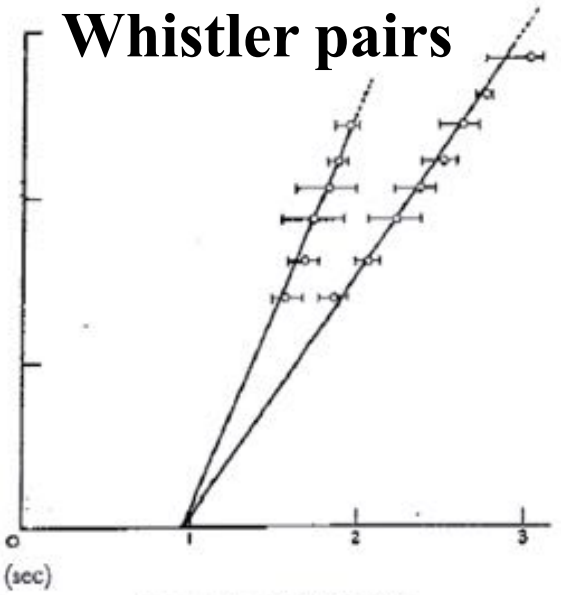


FIGURE 9. Whistler pair.

Triple-D

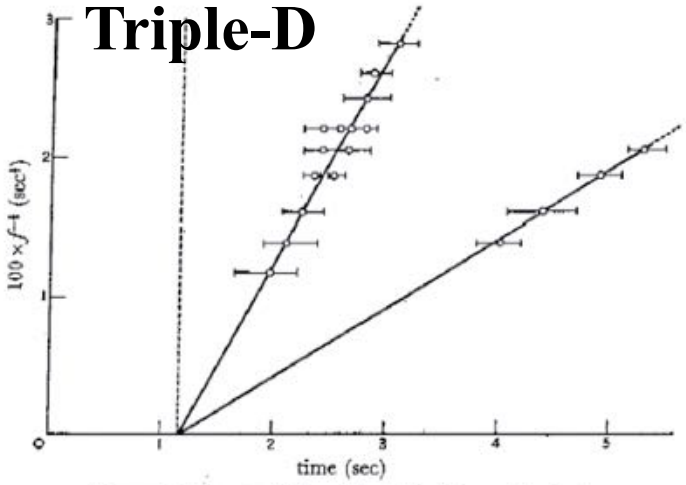


FIGURE 6. Short whistler with triply dispersed 'echo'.

Overlapping

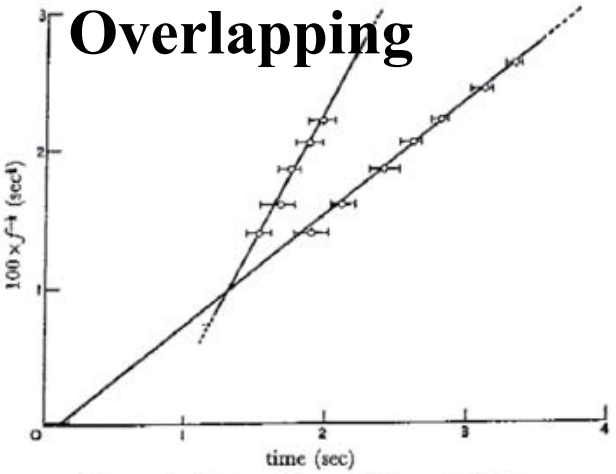


FIGURE 4. Short and long whistler overlapping.

Frequency Dispersion

$$f^{-1/2} = t/D$$

Trace	D	T_0
1	186	-0.5
2	117	11.8
3	53	20.2
4	83	20.4
5	150	20.7
6	75	28.2
7	228	28.2
8	377	28.3
9	532	28.4
10	675	28.5
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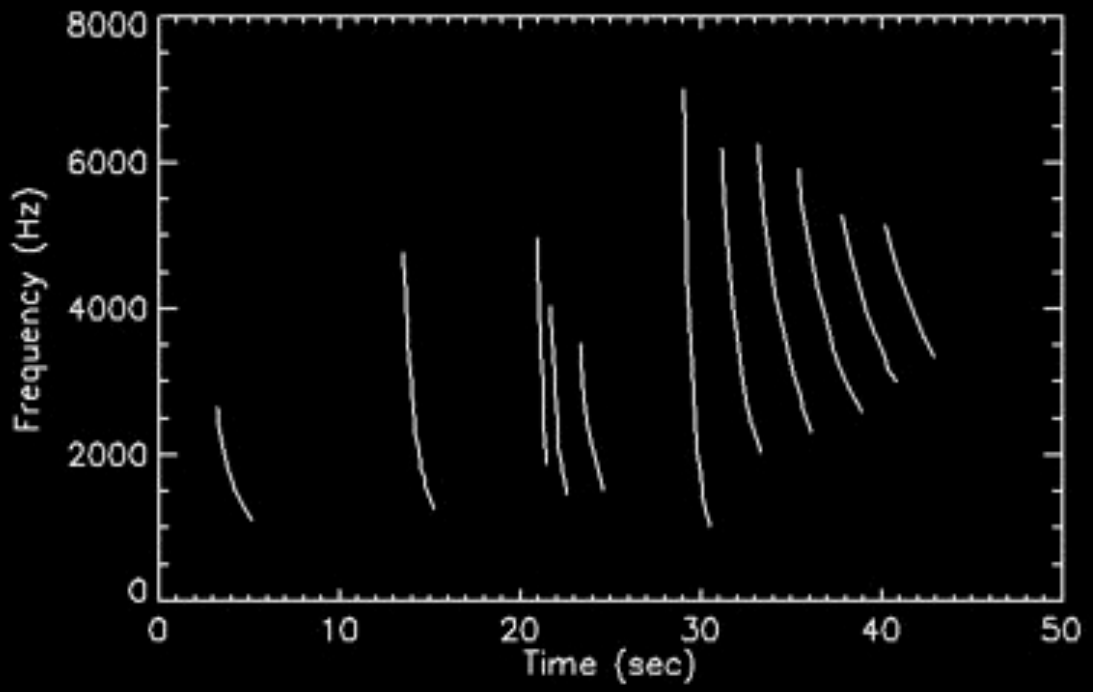
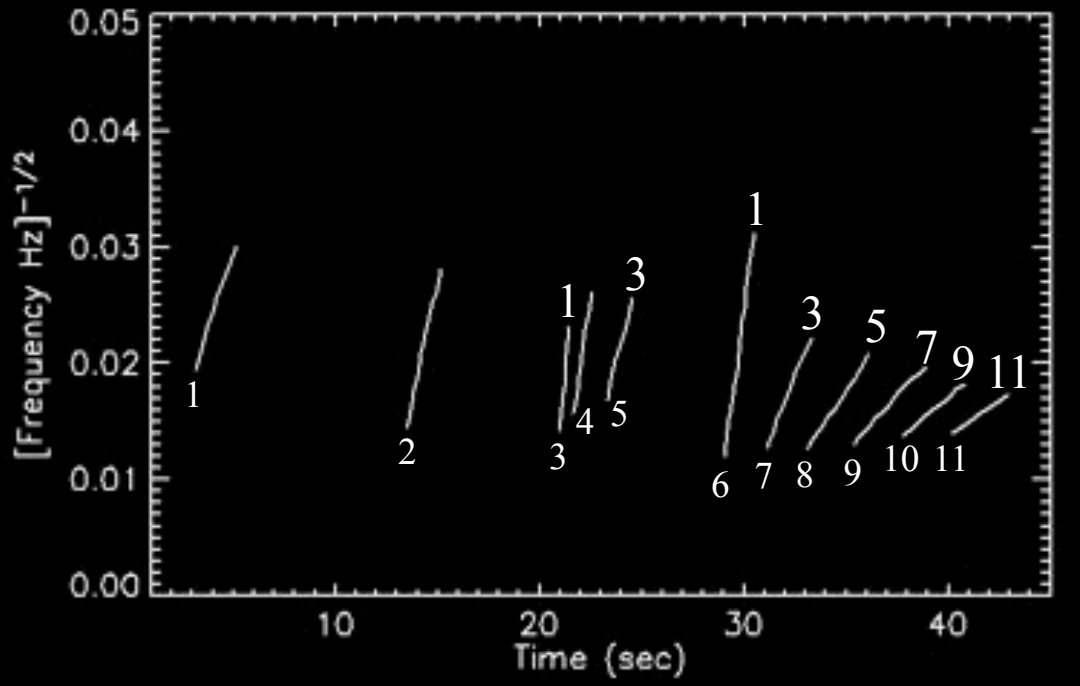
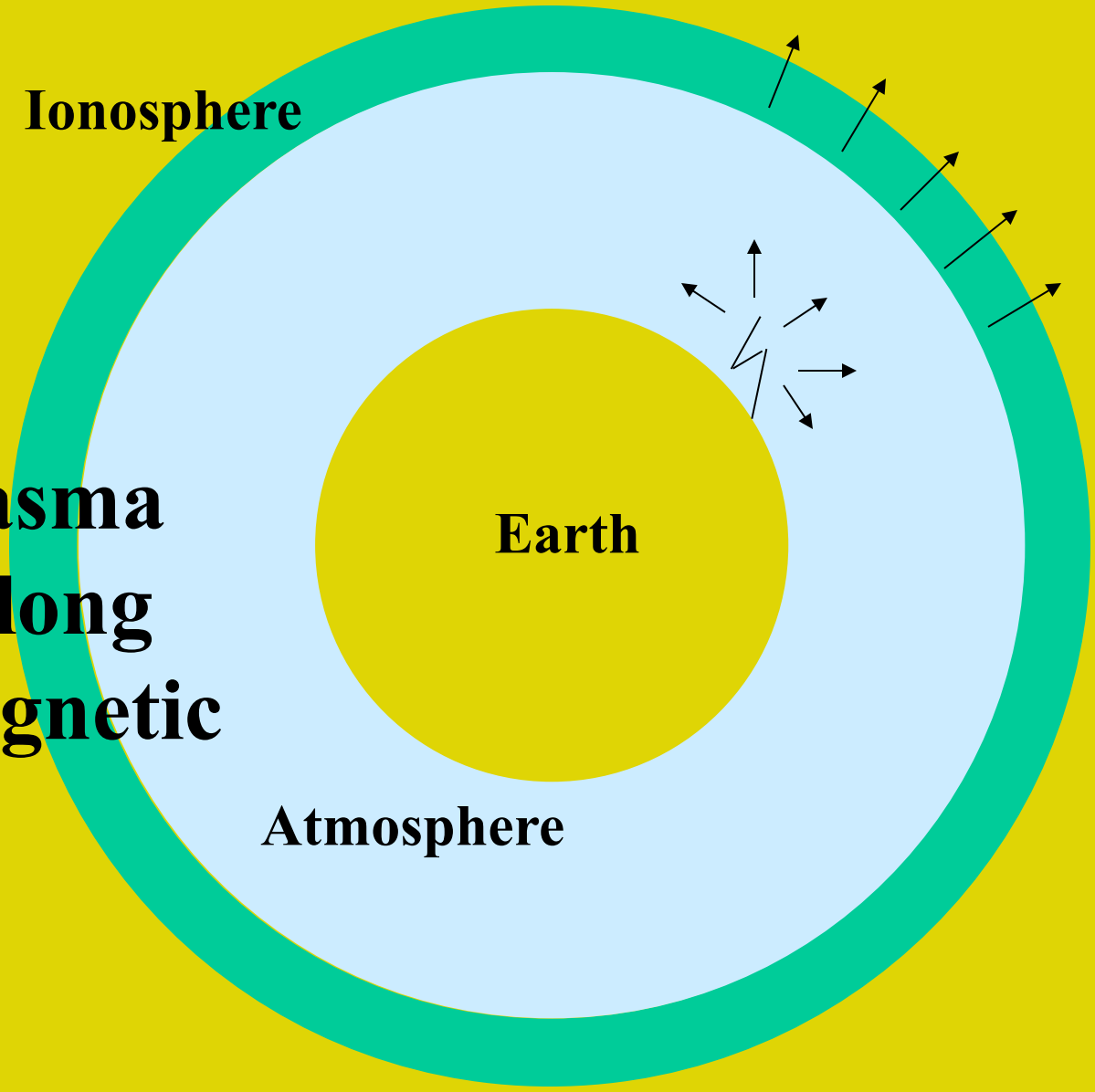




Dispersive & anisotropic ionospheric plasma guides waves along the Earth's magnetic field



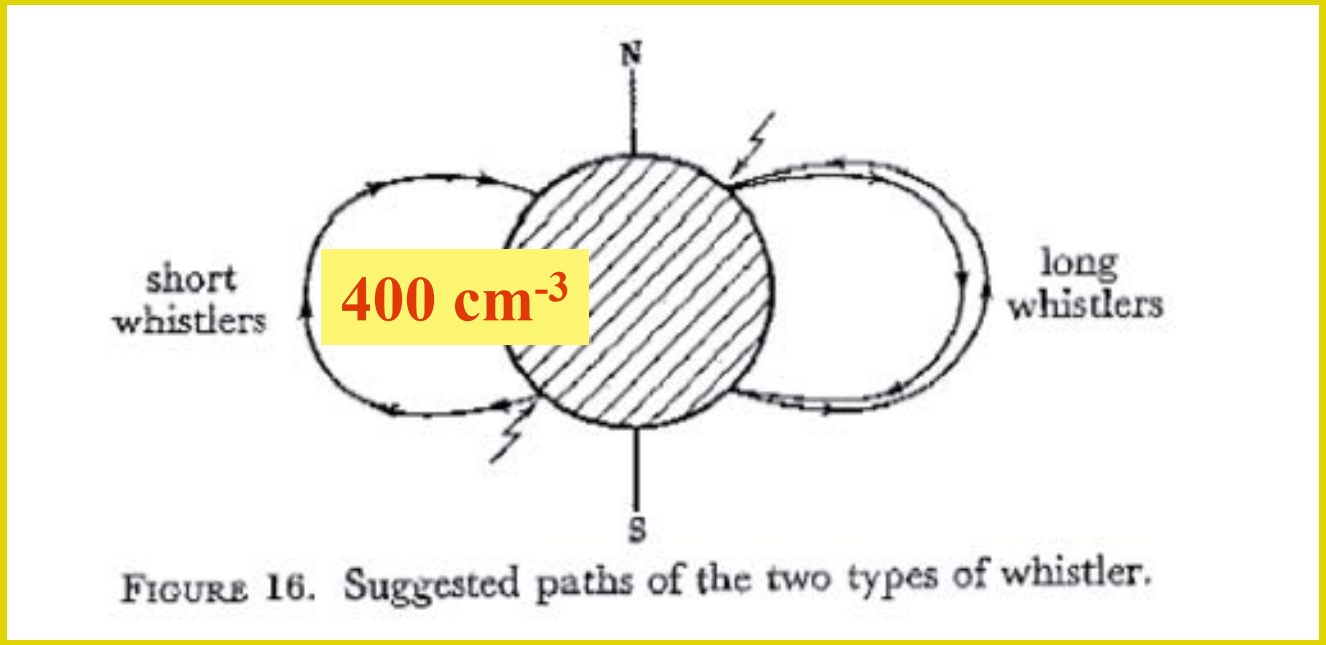


FIGURE 16. Suggested paths of the two types of whistler.

BUT THERE IS A PROBLEM !

Ionosphere can typically only produce D ~ 2 $s^{1/2}$ while dispersions of D ~ 60 $s^{1/2}$ are measured.

WORSE: H. J. A. Ratcliffe, Owen's thesis adviser, presents his results at the 1952 URSI meeting in Sydney, but notes Owen's theoretical interpretation is probably wrong.

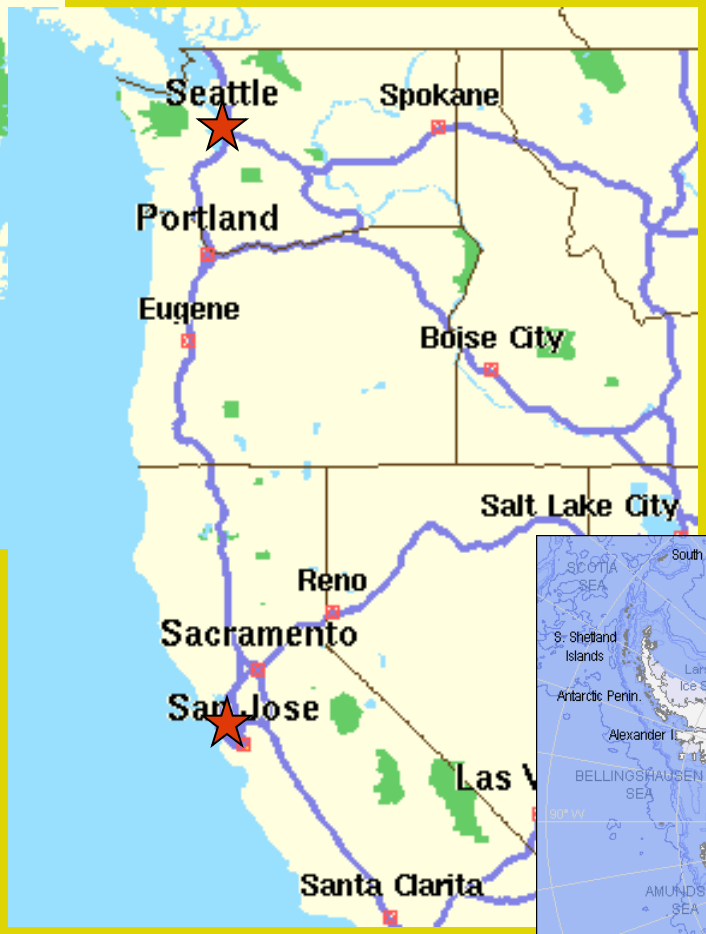
mid – 1950's

Robert Helliwell

"The Father of Whistler Research"

Unalaska, AK

Seattle, WA

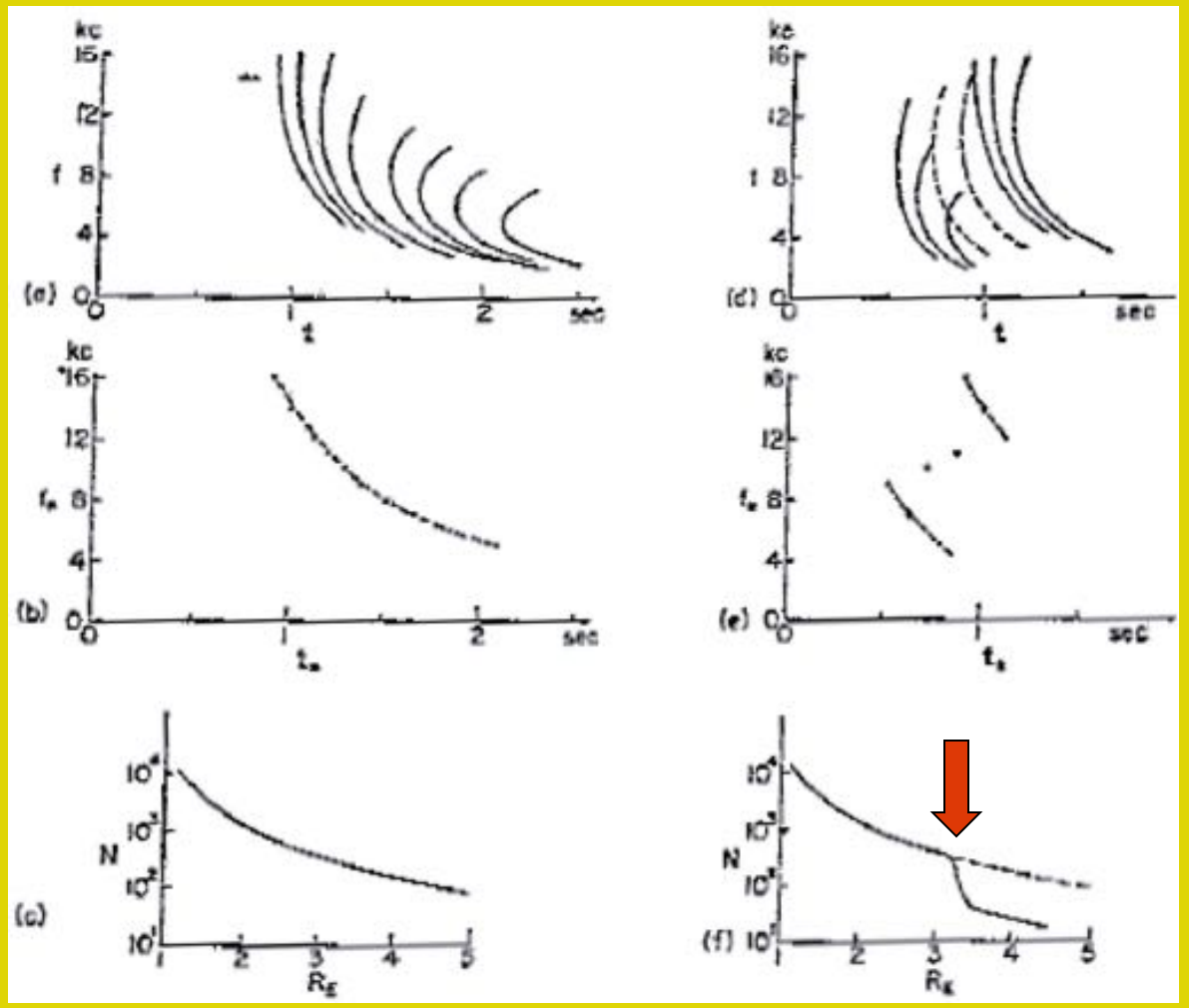


Stanford, CA

Byrd Station, Antarctica

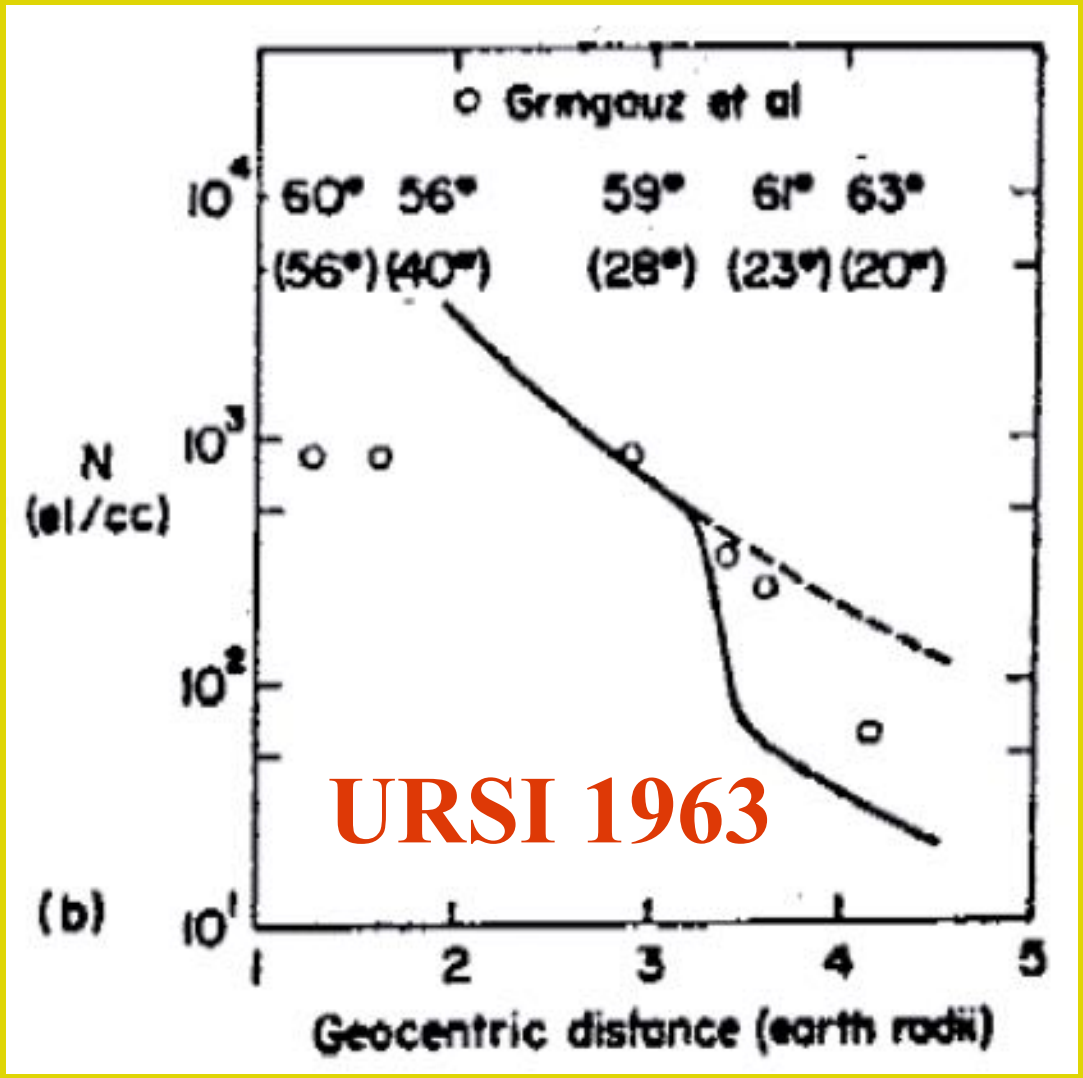
Donald Carpenter, 1963

Discovers the Plasmapause from ground whistlers



Konstantin Gringauz, 1959

Makes the first in-space measurements of the plasmasphere from Luna 2

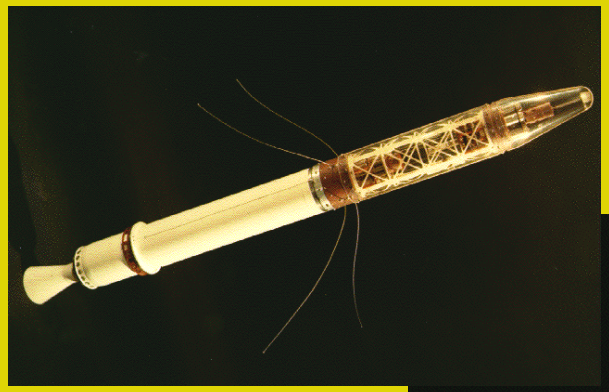


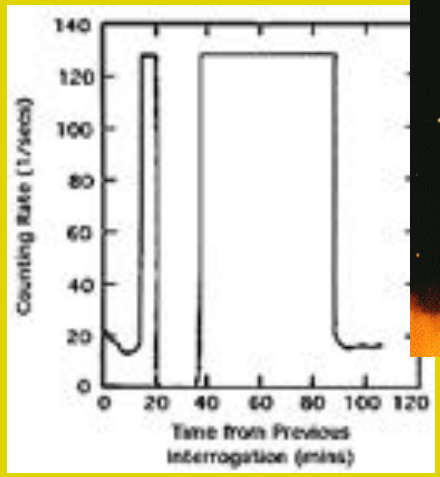
Schumann Resonances

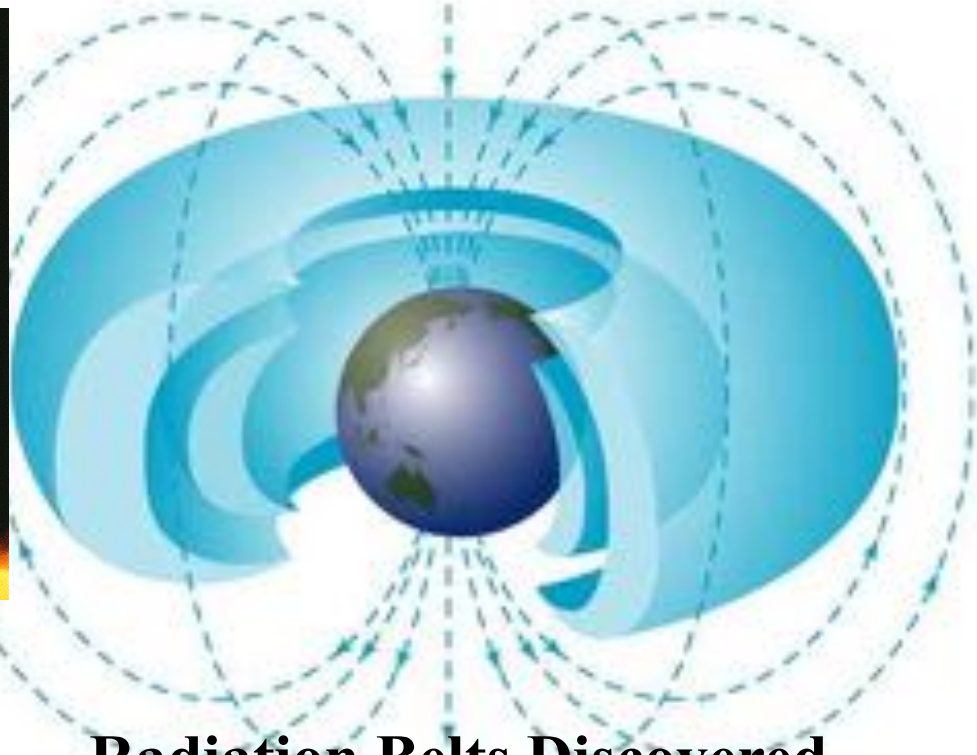
Extremely low frequencies (ELF) around 7.83 (fundamental), 14.3, 20.8, 27.3 and **33.8** Hz

Animation of ELF wave propagation

Explorer 1
January 31, 1958



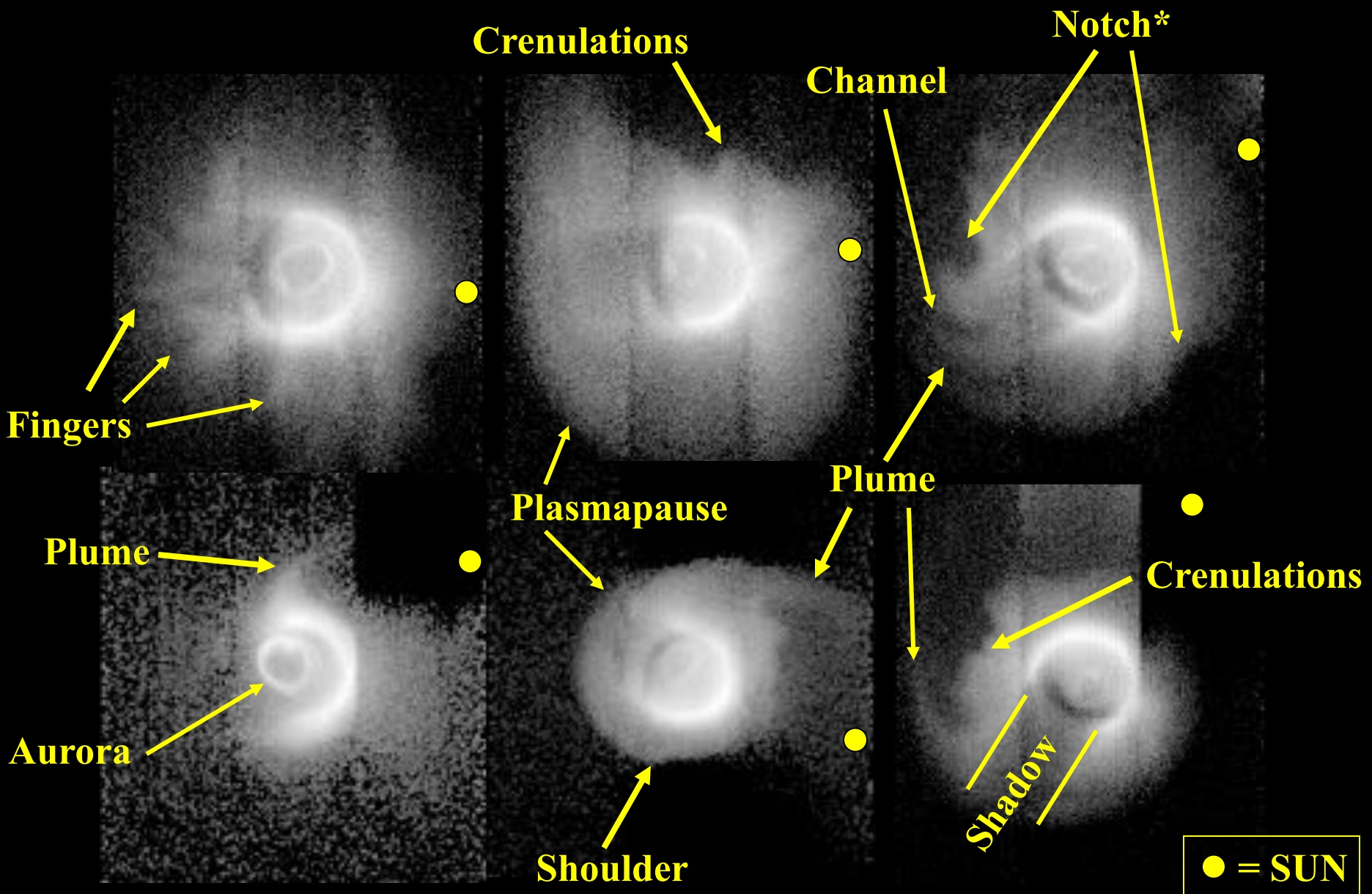




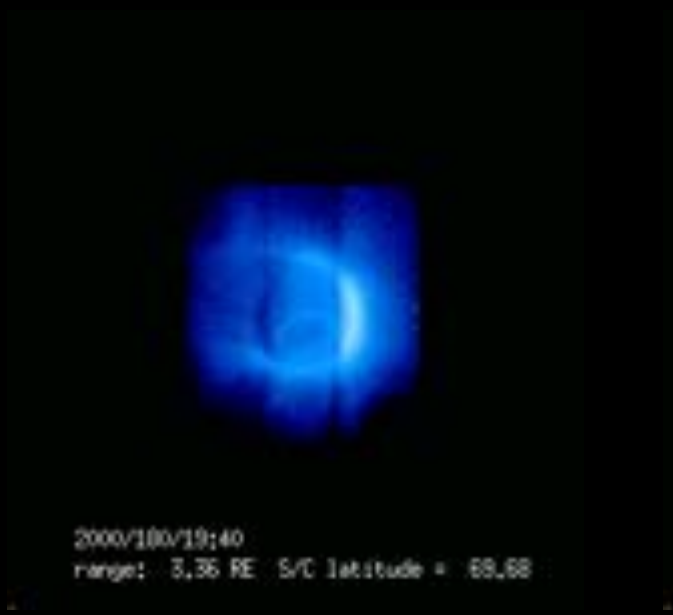
Radiation Belts Discovered

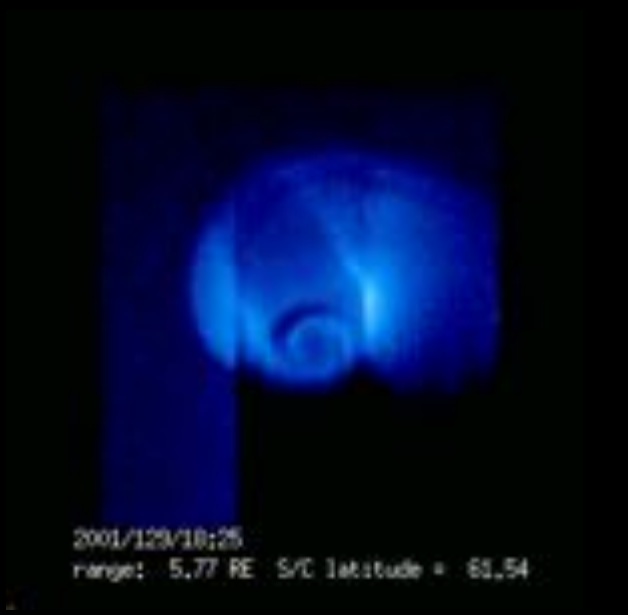

IMAGE
Mission
Launched
March 25, 2000
“Seeing With New Eyes”

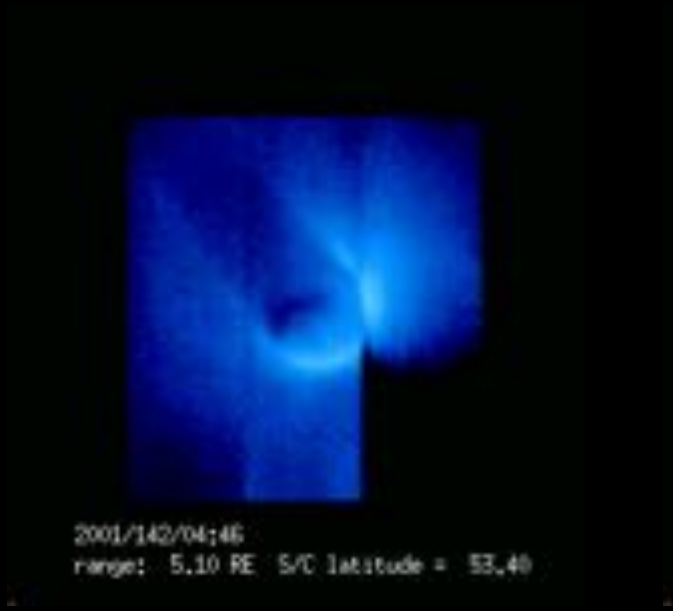
The Plasmasphere We can See!

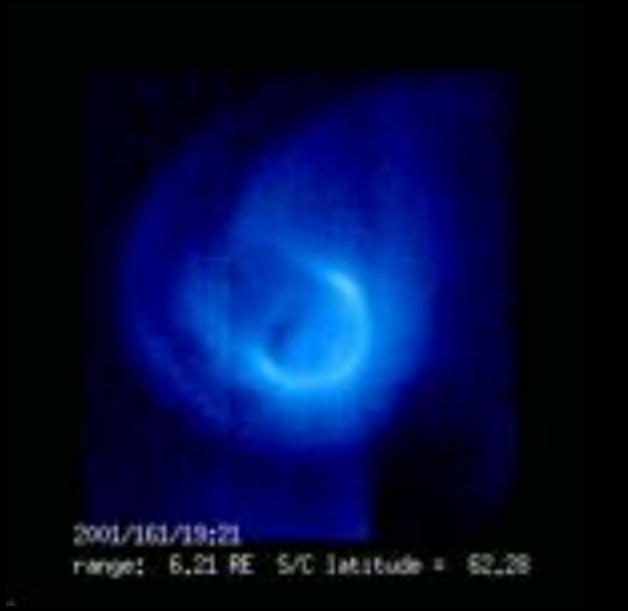


The Plasmasphere is reborn with our new eyes.









Upstream of Bow Shock

Bow Shock-Magnetosheath

Lion Roars - Magnetosheath

Magnetospheric Upper Hybrid Noise

Whistlers – The Plasmasphere

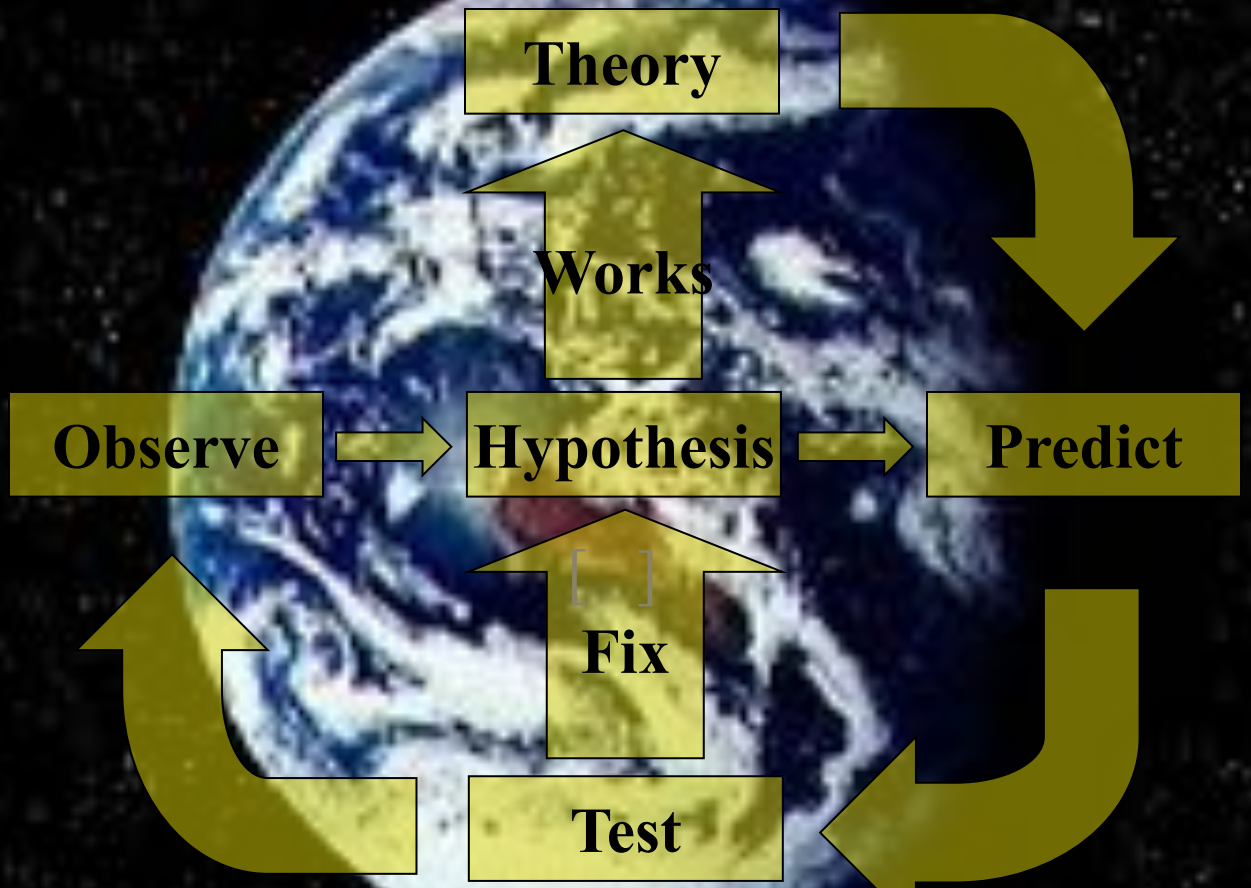
Auroral Kilometric Radiation

Plasmaspheric Hiss

Magnetospheric Chorus

Voyager 1 – Saturn's Ring Plane

Are We There Yet?



http://icecast.msfc.nasa.gov:8000/inspire.mp3